Hot Iron

Issue 19 | "Journal of the Constructors Club" | Spring 1998

Editorial

The cold wet weather of early January stopped much outside farm work leading ultimately to the several new projects mentioned below; however the recent spell of unusually dry and warm weather stimulates the brain. Flicking through the component catalogues, I recently stumbled on a new style of resistive preset capable of taking a shaft (and knob). This costs only a fraction of a normal potentiometer, and through mounting directly on the component PCB, it can reduce the need for extra PCB material for a front panel. With most control wiring as DC or low impedance audio, it makes it easy for the kit builder to add his own full size controls if he wishes, having bought them more cheaply than I can at a rally! This is all good news because it keeps kit prices static or maybe reducing. The new price of 'mechanical' type electronic parts (e.g. pots, knobs and sockets etc.) is out of proportion to their contribution to circuits - compare a pot costing 70 pence at the 100 off rate with a typical digital counter chip having dozens of transistors at 25 pence. Viewed in a simplistic way (ignoring material costs and production run aspects), the cost of the chip making plant is a great many thousands of times that for the mechanical part so it should be the other way round! Nowadys several low cost parts can sometimes replace a single IC at a lower overall kit price but with more work (and slightly increased risk) for the kit builder whose time the kit supplier does not value. I think most builders would favour using several parts if the IC approach doubled the price for that task. What do you think - letters please!

Contents

Kit Developments

The ***Sparkford*** is an 80m CW TCVR using several new ideas which I shall explain in more detail later in this issue. Its low cost, small size and minimum 9 volt supply should appeal for those wanting /P gear. Just £34! The ***Midney*** which I mentioned last time, is now available; it is a single band superhet receiver with phone and CW filters. Any band from 20 to 160m for £49. The ***Antenna Unit***, also mentioned last time, is now available. Designed for QRP purposes, it comprises a *antenna matching unit* using switched inductors with a polyvaricon variable capacitor plus an optional matching *bridge* for adjusting the match conditions. The bridge meter indicates reflected or output voltage, which after matching adjustment for 50 Ohms load to the TX, can be calibrated for power. It suits the more common antenna types and feeders covering 10m to 160m. Price £39. The latest project is a versatile ***Audio filter/oscillator*** kit using an exceptionally sharp cut off clock tuneable low pass filter. A typical filter application would be for CW after a phone bandwidth receiver. The kit can also generate either a single high purity audio sine wave in the range 260 to 4300 Hz or two audio tones suitable for SSB transmitter testing. Price £22. Hope to see you at the QRP Convention. Tim G3PCJ

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel 01458 241224 E mail walfor@globalnet.co.uk

Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year.

Rig Updates

Taunton and Bruton AGC Further work on this aspect mentioned last time confirms the wisdom of running the SL6270 VOGAD chip directly off the 8 volt supply in these rigs. It is also evident that the extra input bias resistors which were originally 10K should be increased to 22K, accordingly I have now changed the instructions and parts lists for both rigs. For those experiencing AGC troubles, in the Bruton, R112 should be replaced by a wire link and R114 should be increased to 22K. For the Taunton, R121 should be replaced by a wire link and R123 increased to 22K. Unless you have problems, I doubt if these modifications will improve any other aspects, so only do them if necessary.

Bruton VFO on 20m Hans Puhringer OE3HPU had already sent me an e mail explaining his modifications to the VFO to improve stability so I was pleased to be able to try them out on another Bruton for myself. He had recommended changing the original TOKO 3335 coil, which has a high μ core for the more stable powdered iron type. Without changing anything else, I found that 12 turns of 24 gauge wire, with a tap at 3 turns for the 2N3819 source connection, on a T50-2 core worked very well. Since there is no trimming device to set the VFO high frequency limit, this had to be done by adjusting the turns on the T50-2. The low frequency VFO limit is set as before using the preset setting the most negative varactor diode voltage. Using 12 turns set the HF limit to just over 8.4 MHz (corresponding to 14.4 MHz RF) - from cold it shifted less than 200 Hz in half an hour.

Hans also commented on the problems of IF breakthrough in central Europe where there are several very high powered AM transmitters operating near to 6 MHz. He suffered quite significant problems until he applied screening to all of the IF section, i.e. both NE612 mixers with their 4066 switches and all of the IF crystal filter. In the UK, I have never had this problem when using open construction *however* these stations can be a very useful source of signals for checking that the IF onwards of the rig is working. Just put your screwdriver, with finger applied, to any hot point in the IF filter - if you get mushy signals, the subsequent stages are working! After these modifications, Hans had some excellent DX contacts using 4 watts into W, VE and VO land. Having found a source of cheap Bulgarian 9 MHz IF filters, he has a new multiband rig in development using ideas out of the Bruton with a Lopen TX. We look forward to hearing about it in the future.

Power Supplies Gerrit ten Veen PA3FOY tells me about his experience with various supplies used with his Taunton. It all started when other stations complained of chirp which Gerrit found to be caused by RF getting into the PSU's regulator circuit leading to an unstable supply to the rig. Plenty of 10 nF ceramic disc capacitors are the cure for this - put them on all supply lines wherever a longish lead enters or leaves a PCB. The wire used for supply leads should err on the large side - the 1 to 2 Amp peak currents on speech peaks can cause significant drops in small wires. Although Gerrit did not tell me his antenna matching unit arrangements, I have a suspicion that poor separation of RF and mains or 0 volt wiring does often lead to problems. I strongly advocate using a link coupled form of resonant antenna matching unit so that the real RF earth is isolated from the rig's 0 volts. Quite often mains earth is connected to the PSU 0 volt line, so without the preferred link coupling, some of the relatively high antenna system RF currents are quite likely to flow into domestic supply earth system and hence the PSU. End fed antennas worked against mains earth are notorious for trouble! If your normal 50 Hz supply uses PME (protective multiple earthing), which depends upon continuity of the electricity supply company's neutral conductor to provide earth fault protection, you must not join mains earth to RF earth and also ensure it is not possible to touch real earth and mains earth at the same time. I do not like PME and much prefer the alternative of using a RCD earth leakage trip.

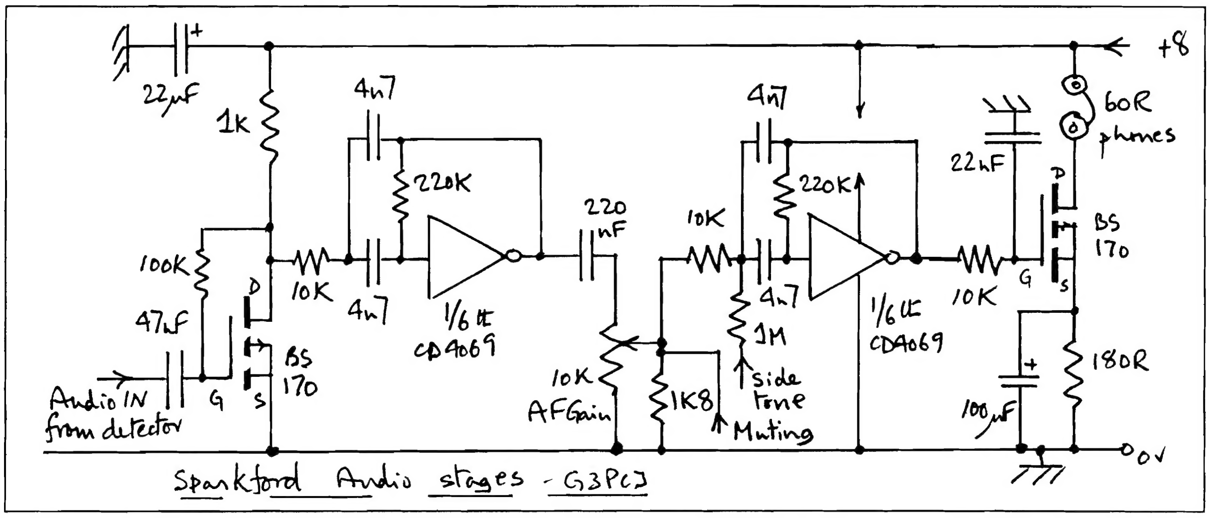
Tips from Joseph Bell G3DII

Zener diodes If you are stuck for a Zener diode in the middle of a project don't forget that most bi-polar transistors exhibit the zener effect between base and emitter with the collector open circuit. Obviously they have to be biased backwards compared to the normal way. Connect the base of p-n-p device to the positive side, with emitter negative. Alternatively, connect the emitter of a n-p-n device to the positive and the base to negative. The heftier the transistor, the greater will be the dissipation that it can handle. Try audio devices like BD139 which shows a zener voltage of between 8 and 12 volts typically. Measure the device's actual zener voltage using the circuit in Hot Iron 17.

LED polarity The lead polarity of LEDs varies between manufacturers and errors can be fatal to the device! There is a simple way to identify the leads. Hold the device up to a strong light. You will see through the package that one lead is directly attached to a largish cup, the other lead having a fine wire going to the cup. The cup is always attached to the cathode lead which should connect to the negative side of the circuit. You may not be able to see the fine wire but the cup is always visible, sometimes with a different shape, but the cathode is always connected to the larger of the internal structures.

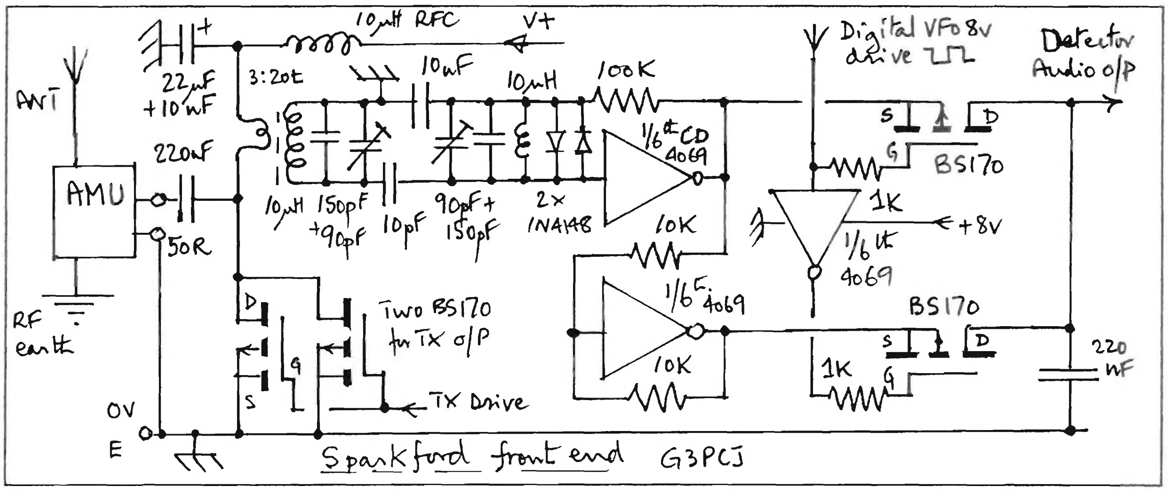
Development of the Sparkford

This design started life as my version of the typical simple 80m CW TCVR. Ingenious as many are, often performance is compromised by using a device for at least two purposes so that it fails to do either or both jobs properly. Some designs also lack essential functions like a VFO, automatic TR changeover or sidetone. Having been brought up on digital devices, I knew a hex CMOS inverter gate package can provide six very cheap 'op amps'. With the output biased to mid supply, the slope of their transfer characteristic shows a voltage gain of times 10. Their cheapness, which allows several to be used, can compensate for low voltage gain. When digital gates are used in this unofficial linear manner, stability can be a problem when negative feedback is used to bias them at the midpoint of the digital transfer curve. The solution is to use the simple unbuffered form of these gates type CD4069 which can work over the wide supply range of about 3 to 18 volts. These inverting gates can be easily arranged as bandpass filters with a gain of 10. The rig actually has two such stages centred on 750 Hz arranged either side of the AF gain control with further audio amplification, and more filtering, both before and after the bandpass filters. On 8 volts, the chip is also fast enough to work as an RF amplifier on 80m. I have previously used a 'digital' signal type VFO in the Wedmore so was confident that they could be used with a 3.58 MHz ceramic resonator tuned by varactor diodes for the main tuning and transmitter frequency offset. Already it looked as though one device type might do several tasks so reducing the number of different types of parts - always a desirable factor. Audio output stages are a problem in a low cost rigs; I do not like the LM386 which is frequently used because it has a narrow recommended supply range. Output for phones would be adequate but not many people have high impedance versions. The common cheap walkman types phones present 60 Ohms when connected in series but even this is too low for the CMOS hex inverter so some form of discrete output device is essential. The BS170 MOSFETs is now cheaper than BC182 etc. and is also more versatile. They are also quite fast so I was happy to add them to the parts list! Further BS170 FETs are actually used for muting and the sidetone oscillator which manages to stop and start with the minimum of thumps! Using these ideas, the main AF circuit that evolved, is shown below.



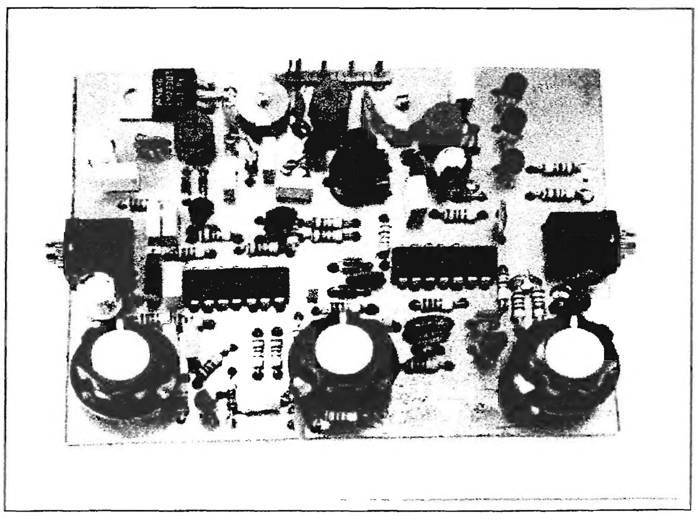
The RX had to be a simple direct conversion type but the choice of detector was not obvious. I wanted to avoid a NE612 because of cost and, to some extent, complexity. A simple diode detector was tried initially but at night it was awful! Wanted 80m signals were swamped by the broadcast stations near 4 MHz even with multiple stages of RF filtering. A doubly balanced form of detector is essential to reject this AM breakthrough. After searching the literature for ideas, I eventually stumbled on an article about switching or synchronous detectors using a quad of special MOSFETs in place of the diodes in a conventional doubly balanced diode mixer. The decision to use BS170's instead didn't take long but avoiding the trifilar wound toroidal transformers was harder! Avoiding that associated with the VFO was easy - use another digital inverter gate, after the VFO oscillator stage, to provide normal and opposite phase signals for the MOSFET switches. How to provide normal and opposite phase RF signals for the MOSFET switches? Solution - use another inverter gate adjusted for a gain of one which is easily arranged! The result is a fairly simple and cheap doubly balanced mixer (see over) which does reject the unwanted AM and which avoids the dreaded coil winding! Using another inverter gate as an RF amplifier lifts the overall gain without risking too much AF gain and possible instability. Further spare gates are used to provide ofset tuning T/R voltage control.

The TX had to have 'automatic' TR facilities but avoiding a relay would be good for the cost and might allow full break-in operation. Some form of TX harmonic suppression is necessary; I prefer a tuned output stage rather than extra low pass filters. The TX output device was to be a FET so it is easy for it to be switched off completely when receiving, thus not loading the RX tuned circuit to which it is connected. By using the antenna matching unit 50 Ohm load impedance (when properly adjusted) as the TX FET drain load, this will define the device drain load, hence power output on a given supply voltage. By directly coupling this to the first stage of the RX bandpass filter, as required for receiving, the receive filter is active on transmit and provides harmonic attenuation. These RX bandpass filters actually use cheap 10 μH TOKO chokes, in order to have the current handling ability needed by the TX, with tuning by preset capacitors. RX front end protection has to be included because the combined RX/TX tuned circuit multiplies up the RF swing way above the safe limit of the RX inverter supply voltage - hence silicon diodes across the second RF bandpass filter coil. They conduct during transmission, with current being limited by the small filter coupling capacitor. On reception, signals are too small for the diodes to conduct. Originally I was going to use an IRF510 as the TX output device but I soon realised that two more BS170s directly in parallel (without heatsinks) could handle the 1.5 Watts output on a 13.8 volt supply implied by the 50 Ohm transmission line load.



The final uncertainty was supplies. The varactor diodes controlling the actual frequency of operation of the nominal 3.58 MHz ceramic resonator, need a very stable voltage. The TX output stage is run off the incoming supply to avoid pumping of the internal varactor supply and this also allows higher RF outputs on higher supply voltages. 8 volts is needed for the varactor supply to get adequate capacitance change and frequency range (50+ Khz). 9 volt operation is desirable for /P. LM317 regulators need a minimum of 2 volt headroom so would not do, so I gave in to the more expensive LM2930-T8 low drop out regulator. I was not able to devise an alternative circuit using only N channel BS170s! It needs a P channel device (see later) and was looking complex compared to the rest of the rig. On 9 volts, the TX produces about 0.75 Watts, or without modification, about 4 watts for short QSOs on 20 volts - above this output does not increase due to lack of RF drive. Finally, I show the complete rig in its working minimalist form below. Remember, that you can easily change the board mounted preset controls and switch for normal ones very easily and more cheaply than I can supply them!

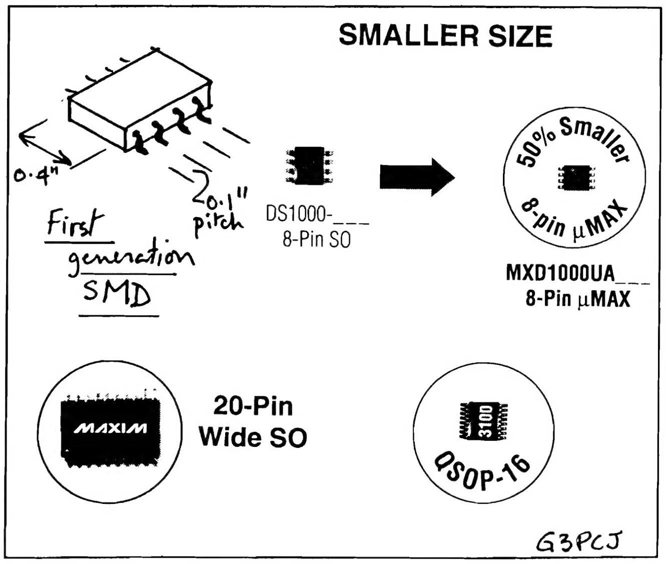
I plan a Sparkford derivative with phasing receiver for single sideband CW reception, audio output for a normal LS or phones, with TX output power of 5 watts on 13.8 volts - I suspect it may have to use the IRF510 or more BS170s! The mechanical style is undecided yet - PCB mounted shafted presets or the normal PCB front panel open style? With presets it will need a 100 x 160 mm PCB but with separate pots it might fit onto 100 x 80 mm. Another low cost derivative might be a double sideband suppressed carrier phone rig. Comments please - Tim.



Surface mounting (and the future!)

One of our regular contributors thought we ought to have something on this very important development but declined my request to write the article! Having very little experience myself, I am somewhat hesitant but here goes! There are two main factors which are leading to the use of increasingly (or is it decreasingly?) small components. The first is that normal through printed circuit board mounting technology just *will not work* as operating frequency is pushed higher and higher. This is because the leads of components and their connecting tracks have significant inductance at frequencies above low UHF - say over 300 MHz. Even at this frequency, an unwanted extra quarter of an inch or 3 mm can be the difference between success or failure of a circuit. Obviously actual circuit impedance levels are relevant but as frequency is pushed up, devices are increasingly designed to have 50 Ohm in and out impedances. Most commercial development effort is directed towards mobile phone uses, or other exotic military or satellite applications where operating frequencies are frequently over 1 GHz with many new devices aimed at 20 GHz plus applications! It makes 80m look like DC! (But you would be surprised how often people come unstuck on 20m when home designing/building!) There are many new 'chips' being developed for these applications such as complete phase locked loops to provide stable oscillators, or complete receiving sub-systems capable of complex modes. The minimum operating frequency of these devices is still many hundreds of MHz so they are practically useless for most home constructors. The commercial need for similar devices to work in the HF or low VHF region is practically zero as ordinary point to point HF radio links are superseded by satellite links or fibre-optic cables. In addition, the newer very high frequency applications tend to use increasingly complex forms of modulation, often digitally based, so that the signals have to be processed by some form of microprocessor to make them useful. The linear functions within these chips are often controlled by some form of digital bus driven by a microprocessor. This trend is demonstrated by the modern mobile phone whose properties are far more dependent on the ingenuity of the programmer, and the user services perceived to be needed, than the underlying feat of wireless communication. The cellar structure of the network, where frequencies are reused and allocated dynamically, would be impossible without very significant base (and mobile) station computing. Commercial radios, even for broadcast domestic use, are now hugely complex in comparison to the typical amateur home built rig!

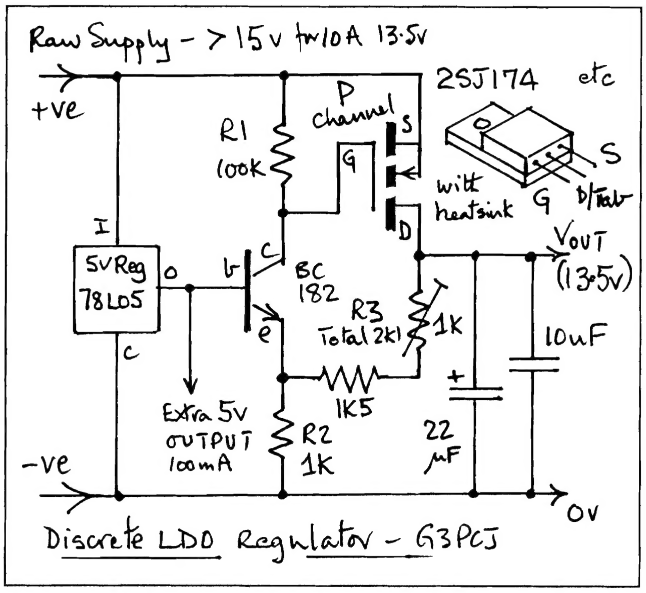
The other factor is *cost*! Size of parts dictates the area of PCB required, and even in my kits, the PCB is a major part of the kit cost so size reduction is important commercially but slightly less so for home building where extra space reduces the risk of errors. Apart from PCB area, having to drill holes for leads is a significant cost as I know! Not only is there the actual drilling time, but it complicates the PCB manufacture through needing more stages and increased chance for errors. Obviously, commercial designs are done with computer controlled drilling jigs but unless the whole process and layout is computerised, it can be very costly for small production runs. Nowadays, most commercial electronic sub-assembly is done with pick and place robotic machines; provided sufficient different parts stocks can be accessed by a particular assembly station, they can be easily reprogrammed to handled multiple product lines. Despite the unit cost of surface mount parts being slightly higher, even in quantity, the cost reductions through PCB area reduction, avoidance of drilling and automated assembly, are well worthwhile.



So what do these devices look like and can they be handled at home? The dimensioned sketch right shows a typical 8 lead first generation surface mount device with those alongside being actual size! (Assuming it will print properly.) There are many standards and packages with various numbers of pins and different plan shapes. How are they soldered? The pick and place machines use a special paste to stick and solder the pads on the underside to matching patterns of the copper tracks. Soldering is done by many different ways automatically but they tend to depend on the whole device being able to withstand soldering temperatures for a short while. The good news is that all modern devices are much

more robust than they used to be, hence there is no need for any form of heatsinking when soldering leads provided you make the joint quickly. Completing the joint within about 3 seconds (about three times longer than usually necessary) is very unlikely to damage modern devices of any package style. If you are going to attempt to build circuits using surface mount devices, you must use a copper track pattern to suit the particular footprint of the device. There are a few specialist development patterns on pre-etched PCBs but these are seldom suited to high frequencies. If you etch your own PCBs, the track pattern is no problem providing the line width of your technique is small enough and dependable. Soldering is best done with a very fine tipped hot iron using the normal 60:40 tin:lead solder. As the devices are so small and light, it is essential to hold them down in the correct place with a third hand while you apply soldering iron and solder to the lead/pad joint area. The use of a large illuminated magnifying glass, on its own mounting arm, is highly recommended. Removing and re-using a multi-pad surface mount device from a PCB is always very difficult (worse than dual in line chips); often it is easiest to cut it in half and accept the loss! I would love to hear about any member's experience and whether builders would like a surface mount project - if so what? Something simple like a wide band active scope probe maybe? Tim

Discrete Low Drop Out linear regulator



Low drop out (LDO) refers to the minimum difference between input and output voltage which permits proper operation; this is often quoted as 2 volts minimum for bi-polar device designs like the 1 Amp fixed voltage 78XX series or the variable LM317T. Using a P channel MOSFET for the main pass device gets this down to fractions of a volt! This is important when a wide variation in load current is expected with the typical poorly regulated raw supply from bridge rectifier plus resevoir capacitor. High output current makes the incoming supply sag so a regulator which reduces the need for more input voltage will make it possible to use a lower transformer secondary voltage, lower voltage capacitors, less heatsink etc. (Or lower raw battery supply). The circuit shown right can be used with any size of P channel MOSFET pass transistor. The minimum drop out voltage is output current times the device On resistance. For the 75 Watt 2SJ174 costing under £4, the on resistance of about 0.13R gives a drop out voltage of 1 volt at 7.5Amps. Max current is 20Amp continuous! Smaller devices like the 0.65 watt BSS110 @ 50 pence can handle up to 0.2 Amps with an $R_{DS(on)}$ of 10R. Both devices can withstand 50 volts between drain and source. The circuit works by using the BC182 transistor in a common base mode so that changes in emitter voltage (derived from the output voltage) cause its collector, and hence the output device gate, to move in the same direction. Thus when the output droops, the MOSFET gate goes more negative turning the MOSFET on harder and so correcting the output droop. The output resistive potential divider R2/R3 is arranged to have a mid point voltage which is normally about 0.65 volts below the BC182 base voltage derived from the fixed voltage regulator. Using a fixed 5 volt regulator enables the common output voltages to be achieved easily - the values shown should provide about 13.5 volts output. The loss of gain through using a resistive potential divider is easily made up by the high collector load R1 for the BC182; since the pass transistor gate looks like a capacitor it does not materially load R1 - only affecting the response to load or line voltage changes. High frequency load regulation is provided by the output capacitors. G3PCJ

Finally, do not forget the

14th Yeovil QRP Convention

The date is earlier this year, ***April 19th*** at the Digby Hall in Sherborne as before. Star attraction is the Rev George Dobbs G3RJV. All the usual attractions - traders, bring and buy, food, talks, demonstrations and Construction Challenge. This is to produce the most power efficient 20m QRP transmitter. Details from Peter Burridge G3CQR, QTHR or Tel 01935 813054. Hope to see you there. Best wishes, Tim Walford G3PCJ